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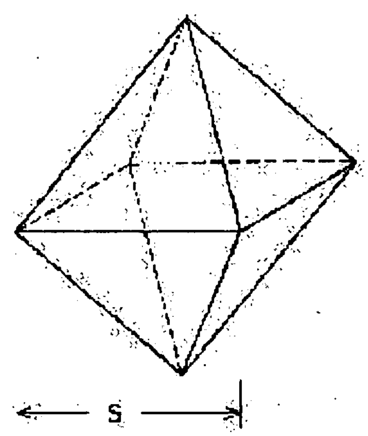
(54) SEMICONDUCTOR SUBSTRATE

(57)Abstract:
PROBLEM TO BE SOLVED: To make it hard to generate slip transition from oxygen deposition even under the thermal compression stress, wherein the slip transition can occur, by containing the carbon having a specific concentration in a semiconductor substrate containing oxygen having the specific concentration.
SOLUTION: In the substrate containing the oxygen of (5-20)×1017pieces/cm3, carbon of 1-3.3×1017pieces/cm3 is contained. At the time of heat treatment in manufacturing an LSI, the many forms of the oxygen deposition is made to be the polyhedron structure. Thus, the slit transition is hard to occur even if thermal stress is loaded, and the LSIs can be manufactured at the high yield.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the semi-conductor substrate which does not have a defect to a component formation field in a detail more about a semi-conductor substrate.
[0002]
[Description of the Prior Art] Most semi-conductor substrates used as substrates for integrated-circuit formation, such as LSI, are manufactured from Si single crystal raised by the approach of pulling up called the Czochrlski method (CZ process) pulled up while rotating Si melt with which it filled up in the quartz crucible.
[0003] When Si single crystal is raised using a CZ process, the quartz crucible itself dissolves in Si melt, oxygen is eluted, and this oxygen is x(5-20) 1017 piece/cm3 in Si single crystal from a solid-liquid interface. It is incorporated by concentration. This oxygen deposits as SiO2 (it is hereafter described as an oxygen sludge) in Si semi-conductor substrate (it is only hereafter described as a semi-conductor substrate) by heat treatment of about 1000 degrees C in the case of LSI manufacture. Since an oxygen sludge has a gettering operation of contamination heavy metal, the existence is indispensable to the semi-conductor substrate of high quality (Masatake Kishino, "basic of VLSI ingredient and process" (1987) p.83).
[0004] In case LSI manufacture is heat-treated to a semi-conductor substrate (it is only hereafter described as a substrate), in a substrate, temperature distribution usually arise. At the time of carrying in at a furnace, especially the temperature of the periphery section of a substrate is higher than the temperature of a core. For this reason, the periphery section of a substrate will expand to a core and heat-and-pressure shrinkage stress will commit it in the periphery section. On the other hand, at the time of taking out from a furnace, the temperature of the core of a substrate is higher than the temperature of the periphery section. For this reason, the core of a substrate will expand to the periphery section and heat-and-pressure shrinkage stress will commit it in a core. If the load of the heat-and-pressure shrinkage stress is carried out to the substrate containing an oxygen sludge, a slip rearrangement may occur from an oxygen sludge (Jpn.J.Appl.Phys., 27 [12] (1988) H.Shimizu and T.Aoshima, and p.2315).
[0005] The X-ray topograph image of a substrate with a diameter of 150mm which contains in drawing 5 the slip rearrangement generated from the oxygen sludge is shown. The linear defect which is presenting white contrast in the photograph is a slip rearrangement. This slip rearrangement is carrying out loop shape, as shown in drawing 6 , and it exercises and spreads the {111} side top of Si. Since, as for field bearing on the front face of a substrate with a diameter of 150mm or more, {100} sides are generally used, the slip rearrangement 1 will exercise toward the front face or rear face of a substrate. Among these, the slip rearrangement 1 generated from the oxygen sludge 2 which exists in the 1/2 or less range of substrate thickness from the front face of a substrate has high possibility of penetrating the front face of a substrate. If such a slip rearrangement 1 appears in a component formation field, it will be thought that it becomes the cause of leakage current generating, and it will become harmful for LSI.
[0006] The slip rearrangement 1 generated on the other hand from the oxygen sludge 2 which exist in

the 1/2 or less range of thickness from the rear face of a substrate become effective [possibility penetrate a substrate front face be low, and / the slip rearrangement 1 which exist in the location distant from the substrate front face enough] for LSI, since the slip rearrangement 1 have a gettering operation of contamination heavy metal (Masatake Kishino, "basic of VLSI ingredient and process" (1987) p.72).
[0007] If the substrate which a slip rearrangement does not generate from an oxygen sludge under heat-and-pressure shrinkage stress can be offered from the above point, the yield of LSI manufacture will improve, if controllable so that a slip rearrangement occurs further only from the oxygen sludge which exists in the 1/2 or less range of thickness from the rear face of a substrate, pollutant gettering capacity will improve and the yield will improve further. However, in the present condition, since offer of the substrate which a slip rearrangement does not generate, and offer of the substrate which a slip rearrangement generates only in a rear-face side are difficult, they are controlling generating of heat-and-pressure shrinkage stress by heat treatment of actual LSI manufacture to extent to which generating of the slip rearrangement by the oxygen sludge does not take place. That is, carrying in at (1) furnace, control of a taking-out rate, control of (2) substrate spacing, etc. are made.
[0008]
[Problem(s) to be Solved by the Invention] However, in heat treatment of actual LSI manufacture, heat-and-pressure shrinkage stress increased according to the time variation of the temperature distribution in a furnace, and other detailed unknown causes, the slip rearrangement occurred from the oxygen sludge, and the technical problem that this slip rearrangement penetrated the front face of a substrate occurred.
[0009] If this invention is made in view of the above-mentioned technical problem and it usually becomes, in order [for which the substrate which a slip rearrangement cannot generate easily from an oxygen sludge under the heat-and-pressure shrinkage stress which can generate a slip rearrangement is offered] to raise the gettering capacity of a pollutant, it aims at offering the substrate which a slip rearrangement tends to generate only from the oxygen sludge which exists in the 1/2 or less range of thickness from the rear face of a substrate further.
[0010]
[The means for solving a technical problem and its effectiveness] The semi-conductor substrate (1) applied to this invention in order to attain the above-mentioned purpose is x(5-20) 1017 piece/cm3. It sets to the semi-conductor substrate containing oxygen, and is 3 one to 3.3x1017 pieces/cm. It is characterized by containing carbon.
[0011] The size of a polyhedron sludge with the same volume as a tabular sludge with a size of 500nm is set to about 150nm. In the case of the polyhedron sludge, this invention person is doing the knowledge of being easy to generate a slip rearrangement, if the size is set to about 200nm or more, and in the case of a tabular sludge, being easy to generate a slip rearrangement, if the size is set to about 230nm or more. The size does not exceed 500nm rash with a tabular sludge. Therefore, if a tabular sludge is changeable into the gestalt of a polyhedron sludge, most sizes of a sludge will be set to about 150nm or less, and reaching the magnitude which generates a slip rearrangement is lost.
[0012] Usually, if it heat-treats at 1000 degrees C and the temperature not more than it, the gestalt of an oxygen sludge will serve as tabular.
[0013] however, the carbon concentration in a substrate -- x(1-3.3) 1017 piece/cm3 it is -- a case -- carbon concentration -- 1x1017 piece/cm3 Compared with the case where it is the following, even if it heat-treats at 1000 degrees C and the temperature not more than it, the gestalt of an oxygen sludge tends (J.Appl.Phys. and 67 [9] (1990) Q.Sun et al. and p.4313) to become a polyhedron.
[0014] Moreover, the upper limit of whenever [dissolution / of the carbon in Si] is 3 3.3x1017 pieces/cm. It is extent (Semiconductor silicon crystal technology (1989), F.Shimura, p.149), and the carbon more than this concentration will not go into Si permutation location, but will deposit as compounds (SiC etc.) with Si. Therefore, 3.3x1017 piece/cm3 The concentration to exceed is not so desirable.
[0015] Therefore, according to the above-mentioned semi-conductor substrate (1), even if it performs heat treatment of 1000 degrees C or less, the gestalt of an oxygen sludge serves as a polyhedron, the size is set to about 150nm or less, and most probabilities to generate a slip rearrangement can be made into

zero.
[0016] Moreover, the semi-conductor substrate (2) concerning this invention is x(5-20) 1017 piece/cm3. It sets to the semi-conductor substrate containing oxygen, and the depth from a front face is 3 one to 3.3x1017 pieces/cm to the 1/2 or less range of substrate thickness. It is characterized by containing carbon.
[0017] According to the above-mentioned semi-conductor substrate (2), even if the thickness from a substrate front face performs heat treatment of 1000 degrees C or less for the reason for the above in the 1/2 or less range (component formation field side), it is hard to generate a slip rearrangement, and since carbon concentration is low in the 1/2 or less range, if the thickness from another side and a substrate rear face performs heat treatment of 1000 degrees C or less, a tabular sludge will deposit and it will be easy to generate a slip rearrangement. This slip rearrangement will heighten the gettering capacity of a pollutant, and can offer the substrate of high quality more.
[0018]
[Embodiment of the Invention] Hereafter, the gestalt of operation of the semi-conductor substrate concerning this invention is explained based on a drawing.
[0019] this invention person investigated the size of the oxygen sludge which can serve as a source of a slip rearrangement after thermal stress has acted by the following approaches. First, five semi-conductor substrates with a diameter of 150mm which contains separately a tabular sludge (about 70nm, 230nm, 330nm, 400nm, and 490nm) by heat treatment were prepared. next, all substrates -- coincidence -- thermal stress -- a load -- carrying out -- TEM (Transmission electron microscopy) -- the size of an oxygen sludge was measured by law and the existence of slip rearrangement generating was investigated. The load of the thermal stress was carried out here by carrying in and taking out the quartz boat which installed the substrate at intervals of 3.3mm at the rate of 15cm per minute in the horizontal-type heat treating furnace maintained at 1000 degrees C. The heat treatment conditions of the usual LSI manufacture install a substrate at intervals of about 3.5mm, it takes out from carrying in or a furnace to the furnace which is the rate of about 5 cm/min and was maintained by about 800 degrees C, and the above-mentioned conditions require thermal stress bigger enough than the thermal stress by which a load is usually carried out. Consequently, possibility that tabular oxygen sludge about 230nm or more would generate a slip rearrangement found out the high thing.
[0020] this invention person prepared further five substrates with a diameter of 150mm which contains separately polyhedron (about 100nm, 130nm, 180nm, 200nm, and 220nm) of an oxygen sludge, and investigated the existence of slip rearrangement generating by the oxygen sludge by the same approach. Consequently, from the oxygen sludge with a polyhedron of about 200nm or more, the possibility of slip rearrangement generating found out the high thing. The above knowledge shows that it is not based on the gestalt of an oxygen sludge, but generating of a slip rearrangement can be controlled by controlling the size to about 200nm or less.
[0021] Here, generally a tabular oxygen sludge can be expressed with the configuration shown in drawing 1 (a), and the oxygen sludge of a polyhedron can be expressed with the configuration shown in drawing 1 (b).
[0022] Volume VL of a tabular oxygen sludge It is expressed with the several 1 following formula, and is [0023].
[Equation 1] VL =4pi/3 and L2 / 2, and b -- here, L expresses diagonal line die length, b expresses thickness, and it is set to b/L**0.007.
[0024] Volume VS of the oxygen sludge of a polyhedron It is expressed with the several 2 following formulas, and is [0025].
[Equation 2] VS = (21/2/3) it is set to S3.
[0026] If [the volume of a tabular oxygen sludge and the oxygen sludge of a polyhedron] the same, it is set to 4pi/3 and L2/2, 0.007, and L=(21/2/3) S3, and the relation of L(2pi and 21/2 x0.007)3 =S3 is materialized, and it will be set to S= 155nm when it is L= 500nm.
[0027] So, except for the oxygen sludge of the very big volume, generating of a slip rearrangement can be controlled by making the gestalt into a polyhedron. In addition, a tabular sludge grows at 1000

degrees C and the temperature not more than it which are generally the typical temperature at the time of heat treatment for LSI manufacture.
[0028] On the other hand, 1x1017 piece/cm3 Existence of the above carbon is 3 1017 pieces/cm. As compared with the case of the following, it is easy to make the gestalt of an oxygen sludge into a polyhedron also at 1000 degrees C and the temperature not more than it.
[0029] (5-20) x1017 piece/cm3 A substrate with a diameter [containing oxygen] of 150mm or more is used, and it is 3 one to 3.3x1017 pieces/cm by ion-implantation. The gestalt of an oxygen sludge tends to serve as a polyhedron at the time of heat treatment for LSI manufacture, and even if the load of the thermal stress is carried out, a slip rearrangement will be hard to be generated by making the above carbon contain. So, manufacture becomes possible about LSI by using this substrate at the high yield. Furthermore, the thickness from the front face of a substrate is 3 1x1017 pieces/cm to 1/2 or less range. By making the above carbon contain In said range (component formation field), it is hard to generate a slip rearrangement in the above-mentioned reason, and on the other hand, when the thickness from the rear face of a substrate makes low carbon concentration of 1/2 or less range, the gestalt of an oxygen sludge tends to serve as tabular, and a slip rearrangement will be easy to be generated. The gettering capacity of a pollutant increases and, so, this slip rearrangement enables it to raise the yield of LSI manufacture further by using this substrate.
[0030]
[Working Example(s) and Comparative Example(s)] Hereafter, the example of the semi-conductor substrate concerning this invention is explained.
[0031] Drawing 2 (a) is the sectional view having shown the semi-conductor substrate concerning an example typically, and ten in drawing is 3 about 15x1017 pieces/cm. The semi-conductor substrate with a diameter of 150mm containing oxygen is shown. Thickness t of the semi-conductor substrate 10 is about 600 micrometers, the semi-conductor substrate 10 is crossed to all fields, and it is carbon about 1x1017 3 or 3x1017 abbreviation/cm/cm 3 It contains by concentration. Drawing 2 (b) is the sectional view having shown the semi-conductor substrate concerning another example typically, and 20 in drawing is 3 about 15x1017 pieces/cm. The semi-conductor substrate with a diameter [containing oxygen] of 150mm is shown. the substrate conjugation method (Fumio Shimura --) to which the semi-conductor substrate 20 is directly joined through the scaling film "Semi-conductor silicon crystal engineering" (1995) Maruzen It is produced by p.229. A front-face side is about 1x1017 pieces / c about carbon. m3 or abbreviation 3x1017 piece/cm3 It is the substrate 22 with a thickness of 300 micrometers which it is thin to the substrate 21 with a thickness of 300 micrometers contained by concentration, and does not have a rear-face side ************ in carbon. thus -- as the semi-conductor substrates 10 and 20 and the example of a comparison of the constituted example -- an oxygen density -- about 15 -- x1017 piece/cm3 it is -- carbon concentration -- about 5 -- x1016 piece/cm3 or about 8 -- x1016 piece/cm3 A semi-conductor substrate is used. it is -- After heat-treating on the conditions carried out in the case of the LSI manufacture to both substrates, the gestalt of about t/6 and the oxygen sludge which existed in each location of abbreviation 5t/6 was observed with the transmission electron microscope (TEM) from each substrate front face. about [from the front face of the semi-conductor substrate 20 concerning an example] -- the TEM image of the oxygen sludge which existed in t/6 -- drawing 3 (a) -- about 5 -- the TEM image of the sludge which existed in t/6 is shown in drawing 3 (b).
[0032] about [from the front face of drawing 3 (a) to the semi-conductor substrate 20] -- it turns out that the gestalt of the oxygen sludge which exists in t/6 is the polyhedron surrounded in respect of {111} of Si. about 5 [moreover,] from the front face of drawing 3 (b) to the semi-conductor substrate 20 -- it turns out that the gestalt of the oxygen sludge which exists in t/6 is tabular [which was surrounded in respect of {100} of Si]. the semi-conductor substrate 10 applied to an example on the other hand -- about t from front face/6, and about 5 -- the semi-conductor substrate which each whose gestalt of the oxygen sludge which existed in t/6 is a polyhedron as shown in drawing 3 (a), and is applied to the example of a comparison -- about t from front face/6, and about 5 -- it turned out that each gestalt of the oxygen sludge which existed in t/6 is tabular as shown in drawing 3 (b).
[0033] The load of the thermal stress was carried out by the approach indicated in the column of the

gestalt of implementation of invention about the semi-conductor substrates 10 and 20 concerning an example, and the semi-conductor substrate concerning the example of a comparison after performing heat treatment carried out in the case of LSI manufacture. And the following procedures compared the generating situation of a slip rearrangement. First, cleavage of both the semi-conductors substrate was carried out to one half. Next, the defective selective etching method was given to the cleavage plane, and the slip rearrangement was actualized as an etch pit. Finally, the depth direction distribution from the substrate front face of slip dislocation density shown in drawing 4 was acquired by measuring the number of an etch pit with an optical microscope.

[0034] Although the slip rearrangement has occurred from the front face of a substrate to a rear face in the thing of the example of a comparison (about 5x1016 carbon concentration/cm 3) so that clearly from drawing 4 , the consistency of a slip rearrangement is very low from the substrate front face to the rear face in the semi-conductor substrate 10 (about 3x1017 carbon concentration/cm 3) concerning an example. moreover -- the semi-conductor substrate 20 (about 3x1017 carbon concentration/cm 3) concerning an example -- about [from a substrate front face] -- t/2 ****** -- the consistency of a slip rearrangement -- very much -- low -- becoming -- **** -- about [from a substrate rear face] -- in t/2 of the range, the slip rearrangement has occurred in same extent as the example of a comparison.

[0035] Moreover, carbon concentration is 3 about 1x1017 pieces/cm. The semi-conductor substrate 10 and carbon concentration are 3 about 1x1017 pieces/cm. The semi-conductor substrate 20 and carbon concentration are 3 about 8x1016 pieces/cm. The result which showed in drawing 4 also in the semi-conductor substrate concerning the example of a comparison, and the almost same result were able to be obtained.

[0036] As mentioned above, the semi-conductor substrate 10 concerning an example is 3 about 1x1017 3 or 3x1017 abbreviation/cm/cm. Carbon is contained. Therefore, even if it receives heat treatment at the time of LSI manufacture, the gestalt of an oxygen sludge tends to serve as a polyhedron, and cannot generate a slip rearrangement easily. So, the consistency of the slip rearrangement penetrated to a substrate front face becomes very low.

[0037] Furthermore, for the semi-conductor substrate 20 concerning an example, the thickness from the front face of a substrate is 3 in 1/2 or less range about 1x1017 3 or 3x1017 abbreviation/cm/cm. Carbon is contained. Therefore, even if it receives heat treatment at the time of LSI manufacture, the gestalt of the oxygen sludge within the limits of this tends to serve as a polyhedron, and cannot generate a slip rearrangement easily. Moreover, the thickness from a rear face serves as tabular by not carrying out the ion implantation of the carbon in the 1/2 or less range, and a slip rearrangement tends to generate the gestalt of an oxygen sludge.

[0038] A gettering operation of the contamination heavy metal by this slip rearrangement improves. Therefore, the yield of LSI manufacture improves further by using the semi-conductor substrate 20 concerning an example 2.

[Translation done.]